Financial Evolution and Interdisciplinary Research

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A knowledge of the historic and philosophical background gives that kind of independence from prejudices of his generation from which most scientists are suffering. This independence created by philosophical insight is − in my opinion − the mark of distinction between a mere artisan or specialist and a real seeker after truth.

Albert Einstein, Letter to Robert Thornton, 1944

Abstract

This paper (summary of the second chapter of the manuscript "quantum dance") talks about the multidimensionality of finance through evolution, philosophy with interdisciplinary features (interweaving of neuroscience, mathematics, quantum physics, biology and artificial intelligence). The path of global financial systems that is dependent on emergency infusions, which in medical terms means that the solution is in the operation of the system itself and perhaps a new global finance, quantum finance? ("Economists aren't trained in money: just imagine the chaos if physicists weren't trained in gravity") and financial decision-making.

Evolutionary ideas have a long history in the social sciences dating back to Malthus, who played an inspirational role for Darwin (Hodgson, 1993). Veblen (1898) coined the term "evolutionary economics" and began the systematic use of the evolutionary approach in the social sciences (Veblen, 1904). Schumpeter (1911) laid the foundations for evolutionary economics in the 20th century. A decisive role in the creation of the economic branch was played by the works of Alchian (1950), Boulding (1981), Downie (1958), D. Friedman (1998), M. Friedman (1953), Hodgson (1993, 2004), Penrose (1952), Nelson (2018) and Nelson and Winter (1982).

The intertwined journey of market outcomes through various cultural traits, trait selection and mutation pressures at different frequencies along with psychological and cognitive bias, network structure, information asymmetry, information waves and institutional environment is the way to study and understand the evolutionary process and social interactions in financial markets (Hirshleifer D ., Shiller R.J., Farmer J.D., Lo A.W., Lo A.W.,). The cultural characteristics of culture and its frequency in its dynamics increase or decrease, changing through individual and social learning. Beliefs and behaviors lead to the transfer of social interactions and observation, implying that culturally transmitted investor ideas or folk models influence trading behaviors and price outcomes. Social finance is characterized by an explicit and broader examination of social transmission processes, cultural characteristics and evolutionary dynamics.

"Evolution, a fact rather than a mere hypothesis, is the central unifying concept in biology. By extension, it affects almost all other fields of knowledge and thought and must be considered one of the most influential concepts in Western thought." – Douglas J. Futuyma.

Introduction

Evolution is a process of continuous branching and diversification from common trunks. This pattern of irreversible separation gives life's history its basic directionality. S. J. Gould

Why do we need an understanding of Evolution?

➢ the process of constant change from a lower, simpler or worse state to a higher, more complex or better state: growth.

➢ a process of gradual and relatively peaceful social, political and economic progress

Science and science-based technologies have changed modern life. They changed the way we look at the universe and how we think about ourselves in relation to the world around us.

Biological evolution is one of the most important ideas of modern science. Evolution is supported by an abundance of evidence from many different fields of scientific research. It is at the foundation of modern biological sciences, including biomedical sciences, and has applications in many other scientific and engineering disciplines.

As individuals and societies, we are making decisions now that will have profound consequences for future generations. To what extent should we use our new understanding of biology at the molecular level to change the characteristics of living things?

None of these decisions can be made wisely without considering biological evolution. People need to understand evolution, its role within the larger scientific enterprise, and its vital implications for some of the most pressing social, cultural, and political issues of our time.

Science and technology are so widespread in modern society that students increasingly need a good education in the fundamental concepts, applications and implications of science. Because evolution has served and will continue to serve as a critical foundation of biomedicine and the life sciences, helping students learn and understand the scientific evidence, mechanisms, and implications of evolution is fundamental to a high-quality science education.

Understanding evolution is the path of current knowledge about knowledge of networks and management of complex movements of finance and the financial market, because "as underwriters, we tend to look at the world from the rearview mirror, very retroactively. We need to get out of that mindset and look instead at the risk landscape that we're in today. How do we anticipate the risk and evolve our ways of thinking to be able to better price, underwrite, and ultimately provide the capacity that's needed?" (Juan C. Andrade). The young generation of scientists (economics/finance/neuroscience/quantum physics/mathematics...) will change the way the financial field works in the long term. It will be a process. We cannot overnight demolish the intellectual edifice that has dominated the past four decades.

According to Oxford historian Peter Frankopan, we are witnessing the disintegration of the global order. In a period of history marked by the Western financial crisis, the global coronavirus pandemic, war in Europe, growing national debt and political instability in developed democracies, the Western era is coming to an end. The global order is steadily moving towards a "post-American world" or "post-Western world". At the heart of this change is the rise of China and the emergence of a multipolar system.

An interdisciplinary view (the interweaving of neuroscience; zona incerta, neocortex; when the brain forms memories, it combines signals coming from the environment (bottom-up) with those generated by itself (top-down). So-called top-down signals can, for example, be influenced by our current goals or past experiences; AI, helpful tool in the development of an intelligent approach in financial decision-making, through sophisticated technology but also thinking about technological singularity, quantum physics and finally everything is physics and information, allows us to dive deeper into the evolution and current complex management system, giving us guidelines for development and growth.

In this chapter, we will talk about the multidimensional nature of finance through evolution, philosophy with interdisciplinary features (the interweaving of neuroscience, mathematics, quantum physics, biology and artificial intelligence).

The second chapter introduces us to the magic mirror of the present of the third chapter of the global financial systems, which is now dependent on emergency infusions, which in medical terms means that the solution is in an operation on the system itself and perhaps a new global finance, quantum finance ("Economists aren't trained in money: just imagine the chaos if physicists weren't trained in gravity") and financial decision-making.

A knowledge of the historic and philosophical background gives that kind of independence from prejudices of his generation from which most scientists are suffering. This independence created by philosophical insight is – in my opinion – the mark of distinction between a mere artisan or specialist and a real seeker after truth.

Albert Einstein, *Letter to Robert Thornton*, 1944

by including philosophy in evolution and interdisciplinary research….

Philosophy and science share the tools of logic, conceptual analysis, and rigorous argumentation. Yet philosophers can operate these tools with degrees of thoroughness, freedom, and theoretical abstraction that practicing researchers often cannot afford in their daily activities.

"New" biology (B. Lipton) reveals that evolution is neither random nor predetermined, but an intelligent dance between the organism and the environment. In order to prosper in the future, we must return to living according to the principles of Nature. In a dynamic, multimedia journey from the microcosm of the cell to the macrocosm of the mind, the "new" biology is based on quantum physics and epigenetics that reveals how our thoughts, attitudes, and beliefs shape the conditions of our bodies and our place in the world." There are profound similarities between financial systems and the biosphere. Both are complex adaptive systems in which individual agents act to strengthen their own interests and goals, which leads to self-organization and the emergence of new features.

And scientific research in the past decades has revealed that the electrical activities of the brain are correlated with the phenomenology of consciousness. Thus, cognitive science increasingly uses physical principles for its analyses. Recently, the Fermi Mind Hypothesis (FMH) has been proposed to explain the difficult problem of consciousness. For decades, quantum cognition has considered quantum theory to model cognitive phenomena such as memory, language, decision making, and social interaction. String theory (String theory is one of the proposed methods for producing a theory of everything, a model that describes all known particles and forces and that would supersede the Standard Model of physics, which can explain everything except gravity. Many scientists believe in string theory because of its mathematical beauty. The equations of string theory are described as elegant, and its descriptions of the physical world are considered extremely satisfying") can explain social comparisons and the tendency to proportionality. The evoked cycle represents the energy-informational cycle between the cortex and the limbic brain, which is built on the resting state of the brain. Since gravity acts by pressure, the perception of time is motivated by emotions. Sensory information, which reflects spatial relationships, is transformed into temporal relationships of memories and decisions. Positive emotions represent an endothermic cycle directed towards the future. Negative emotions correspond to information overload; the exothermic process imposes a high energy demand on the brain. Energetic consequences can explain the evolution of intellect as well as mental illness.

Evolution refers to short-term, relative optimality in relation to other participants in the system. In the biosphere, natural selection improves reproductive success relative to reference values of other genomes, within and between species. Evolutionary change can therefore be understood in terms of diversity, small differences in reproductive rates among individuals over time leading to large differences in populations. Even the mechanisms of evolution themselves - including those that create new variations - are subject to constant change. In the financial world, the evolutionary forces of mutation, recombination, reproduction and selection often act on financial institutions and market participants through direct competition, financing tooth and claw. Financial concepts and strategies are thus reproduced through cultural transmission and adoption based on their success in the marketplace. These strategies undergo financial innovation, analogous to mutation or genetic recombination in a biological system, but take place at the level of information and abstract thinking in financial contexts. It is "survival of the richest".

Building bridges - the evolution of finance deep roots in scientific disciplines

Evolutionary ideas have a long history in the social sciences dating back to Malthus, who played an inspirational role for Darwin (Hodgson, 1993). Veblen (1898) coined the term "evolutionary economics" and began the systematic use of the evolutionary approach in the social sciences (Veblen, 1904). Schumpeter (1911) laid the foundations for evolutionary economics in the 20th century. A decisive role in the creation of the economic branch was played by the works of Alchian (1950), Boulding (1981), Downie (1958), D. Friedman (1998), M. Friedman (1953), Hodgson (1993, 2004), Penrose (1952), Nelson (2018) and Nelson and Winter (1982).

Traditional ways of thinking about finance, dating back to Hilferding, emphasize the importance of concentration and economies of scale. These approaches ignore the rich "biodiversity" that characterizes the financial world. But the role of natural selection has also been neglected. Of course, natural selection in the financial world is not entirely analogous to the processes first described by Darwin and elaborated by modern biologists. There is conscious adaptation as well as random mutation. There is such a thing as "intelligent design" in finance, with regulators and legislators acting quasi-divine, putting dinosaurs on life support. The danger is manifested in interference with natural market processes that could potentially end up distorting the evolutionary process, hindering Schumpeter's "creative destruction".

The intertwined journey of market outcomes through various cultural traits, trait selection and mutation pressures at different frequencies along with psychological and cognitive bias, network structure, information asymmetry, information waves and institutional environment is the way to study and understand the evolutionary process and social interactions in financial markets (Hirshleifer D ., Shiller R.J., Farmer J.D., Lo A.W., Lo A.W.,). The cultural characteristics of culture and its frequency in its dynamics increase or decrease, changing through individual and social learning. Beliefs and behaviors lead to the transfer of social interactions and observation, implying that culturally transmitted investor ideas or folk models influence trading behaviors and price outcomes. Social finance is characterized by an explicit and broader examination of social transmission processes, cultural characteristics and evolutionary dynamics.

To a large extent, evolution also refers to interaction with the unknown, because the scope of possible changes in the environment is enormous. The interplay of exploration (through which new solutions are tested) and exploitation (through which the best solutions are implemented) is characteristic not only of biological evolution through natural selection, but also of the way investors, companies, and financial institutions must divide their time and effort to survive. The compromise emphasizes the importance of preserving diversity and heterogeneity in financial markets, allowing sufficient exploration, through financial innovation, to produce essential diversity. As in purely biological systems, the balance between exploration and exploitation will depend on context, and on endogenous as well as exogenous sources of variability and uncertainty/uncertainty.

Evolution can answer many fundamental questions about the nature of risk. No form of research is without risk, whether in the biosphere or in the financial world. Species have evolved behavior to successfully manage risk, whether in their foraging strategies, prey capture methods, predator avoidance methods, or mating strategies. Genomes will also develop different strategies when faced with idiosyncratic versus systematic risk in their environment. Risk aversion and risk-seeking behavior can be understood as a consequence of environmental pressures on the evolutionary history of the organism. A similar dynamic applies to participants in model evolutionary systems, where a diverse collection of economic behaviors, including cooperation, can be generated from various factors in the environment.

Market participants (managers and investors) acquire and transmit an understanding of the functioning of the economy and the market - Hirshleifer calls this folk economic and financial models. Folk financial models often reflect shallow knowledge, as they are embodied in Wall Street phrases such as "dead-cat bounce" and "Don't fight the Fed". Folk models sometimes they are tied to vivid narratives that help them spread from person to person (Shiller R. J.).

Financial history is essentially the result of institutional mutations and natural selection. Random "drift" (innovations/mutations not driven by natural selection, just happen) and "flow" (innovations/mutations that

play a role, like when Chinese banks adopt American practices), "coevolution" is possible, when different financial species work and adjust together (hedge funds and their prime brokers), however market selection is the main driver. Financial organisms are in competition with each other for the final funds. At certain times and in certain places, certain species can become dominant. But innovation according to competing species, or the emergence of completely new species, prevents any permanent hierarchy or emerging monoculture. So the law of "survival of the fittest" applies. An institution with a "selfish gene" that is good at "self-replication" (and self-perpetuation) will seek to perpetuate itself and reproduce (Dawkins 1989). Of course, this cannot result in the evolution of a perfect organism, also, the natural world, evolution is not progressive (especially from the followers of Herbert Spencer).

According to Ferguson (2008), six features share the financial world and the true evolutionary system:

➢ "Genes", in the sense that certain business practices have the same role as genes in biology, allowing information to be stored in "organizational memory" and transferred from individual to individual or from company to company when a new company is created.
➢ Usually, the potential for spontaneous "mutation" in the economic world is called innovation and primarily, although not always, technological
➢ Competition among individuals within a species for resources, with outcomes in terms of longevity, determines which business practices exist.
➢ A mechanism for natural selection through the market, distribution of capital and human resources, and the possibility of death in cases of poor performance, i.e. "differential survival".
➢ Scope of specification, preservation of biological diversity through the creation of completely new "species" and financial institutions.
➢ Extinction range, at which species become completely extinct.

Any shock to the financial system must result in casualties. Left to their own devices, "natural selection" should act quickly to eliminate the weakest institutions in the market, and that means the successful gobble up the weak. But most crises also introduce new rules and regulations, as legislators and regulators rush to stabilize the financial system and protect the consumer/voter. The critical point is that possibility of extinction which cannot and must not be removed by excessive precautions. As Joseph Schumpeter wrote more than 70 years ago, "This economic system cannot do without the ultima ratio of total destruction of those existences which are irreversibly linked to the hopelessly maladjusted. " According to him, this meant the disappearance of "those companies that are not viable" (Schumpeter 1934).

Evolutionary theory for financial regulators implies that diversity is as desirable in finance as it is in nature. Would the whole world move closer to a model - whether designed in Washington, Basel or Beijing - of an international system that would be perhaps more vulnerable to mass extinction than it is now. However, today's role of technology in the financial system leads to a different trajectory of evolution.

An interesting epigenetic study reveals that children born during a historic recession have markers of accelerated aging later in life.

(..let's imagine?) .The worst recession in US history shaped how well people would age—before they were even born. Researchers have found (Schmitz, L. L. & Duque, V. , 2022) that the cells of people who were conceived during the Great Depression, which lasted from 1929 to 1939 and at its peak left about 25% of the American workforce unemployed, show signs accelerated aging. "What we experience in the first nine months of our birth can affect our entire lives," "I think we can agree as a society that experiencing a recession before you're even born shouldn't affect how long you live." (L.L. Schmitz).

Evolutionary and financial approaches to financial markets, including the econophysics literature (understanding the behavior of financial assets and the evolution of the economy is still important today), mostly derive or simulate the aggregate consequences of zero-intelligence rules on the behavior of participants. These approaches provide insights but do not address the effects of participants meaningfully striving to optimize (even if imperfectly). Social finance involves participant-based modeling of transmission biases, but further allowing for the effects of transmission biases when agents form beliefs and meaningfully choose actions. Scientific papers and discussions of the physicist community about risk and market decline

are also conducted with work on betting markets, as well as studies on speculative peaks that occur in real estate markets.

Philosophers' debates about Darwin's theory of evolution went through a series of historical phases, from indifference (in the first hundred years), to criticism (in the 60s and 70s) and enthusiasm and expansionism (around 1980). Darwin emphasized that he had no aptitude for philosophy: "The power of following a long and purely abstract train of thought is very limited; Moreover, I should never have succeeded in metaphysics or mathematics " (Darwin 1958). It wasn't false modesty; it was the simple truth. Nevertheless, he was a great synthesizer of facts and theories, and very thoughtful about scientific methods (he appreciated Sir John Hershel's "A Preliminary Discourse on the Study of Natural Philosophy"; see Gildenhuys 2004)), somewhat akin to a philosopher).

What is the essence of human nature and behavior that defines our own existence? Despite centuries of debate, there is little research that examines the relationship between the development of early philosophical theories and the literature describing human nature and potential with topics currently associated with evolutionary theory (natural selection, compassion, greed, and conflict). Human behavior is complex in that it can often show contradictory characteristics (prosocial and benign, as well as antisocial and aggressive tendencies) of different groups of people in similar environmental conditions. The view of recent philosophers, political philosophers, and romantic authors (Thomas Hobbes, Alexis de Tocqueville, Jean Jacques Rousseau, John Locke, and Mary Shelley) who describe and rationalize human nature as biologically "brutal and savage" for the purposes of survival ultimately depicts human existence in chaos and conflict. We can perceive and recognize the inherent contradiction and relationship between evolved egoistic needs among individuals with responsibilities and interpersonal needs of civic engagement and cooperation as a fundamental requirement of sustainable human existence in a democratic community.

Can the same patterns seen in biological evolution apply to stock market behavior? Many of the same "causal interactions" and "survival elements" can be found there as in nature.

The pandemic changed resources, destroyed companies and subtly adjusted habits, so the economy evolved. Most economic models do not treat the evolving economy, which is undergoing constant change. Instead, they describe it in terms of its equilibrium, the steady state in which prices balance supply and demand, or the path the economy takes back to stability when a shock disrupts its rest. Although such strategies have sometimes proved useful, the economy is poorer because of the neglect of the evolutionary nature of the economy. The evolutionary approach recognizes that the past informs the present, economic choices are made within and based on historical, cultural and institutional contexts.

The philosophy of evolutionary biology is a major subfield of the philosophy of biology that deals with the methods, conceptual foundations, and implications of evolutionary biology. It also refers to the relationships between evolutionary biology and neighboring fields, such as biochemistry, genetics, cellular and molecular biology, developmental biology, and ecology. Initially, many questions of central importance to biological philosophy grew out of the general philosophy of science. The study of the evolution of human behavior and cognition has been scrutinized as an example of the potentially harmful and positive influence of values in science. In current times, philosophers of biology collaborate with and draw on evolutionary biology to analyze broader philosophical questions and problems, such as the nature of consciousness, or engage directly in debates within evolutionary biology. It should be emphasized that philosophers have engaged in conceptual and methodological debates within evolutionary biology about the appropriate conditions for testing hypotheses. Hypothesis generation has long been an exclusively human domain. However, scientists are beginning to look to machine learning to produce original insights. They design neural networks (a type of machine learning setup with a structure inspired by the human brain) that suggest new hypotheses based on patterns the networks find in the data rather than relying on human assumptions about adaptation, units, targets or levels of selection, mechanisms and measures of heritability, methods of phylogenetic inference and classification and systematization. In this category, the boundary between science and philosophy is erased; philosophers and biologists are also participants in many of these discussions.

Financial markets are explored as evolving biological systems. Different investment strategies compete for market capital invested in long-term, dividend-paying assets. Some strategies survive and some die out. Thus

financial markets that are modeled from a biological perspective where investment strategies and wealth take over the role of species and their ability. Dividends paid by a company's stock are determined by the market value of the company and random events. This creates a feedback loop between the distribution of wealth and the production of dividends that are paid out on investment strategies. The conducted analyzes resulted in an explicit description of the evolutionary stable investment strategy λ (evolution in pecunia, 2020). Dividends are not exogenous, but increase with wealth invested in assets, as is the case in a manufacturing economy. This could create a positive feedback loop where more investment in an asset leads to higher dividends which in turn lead to more investment. Nevertheless, it is possible to identify an evolutionary stable investment strategy. The problem is studied in a framework that combines stochastic dynamics and evolutionary game theory. Basically, the model uses only objectively visible market data, in contrast to traditional settings that rely on invisible characteristics of investors (utilities and beliefs). The method is analytical and based on mathematical reasoning.

I can understand the current habits of the economics profession only by examining the field's own history. In the 19th century, the discipline that would become economics was an evolutionary science in several senses. Thinkers from different backgrounds competed to offer theories that best explained economic activity, while, at the same time, its practitioners saw the subject of their study as an extension of the biological sciences.

Accepting evolution requires the analysis that everything that exists must be the result of evolutionary processes. Academic disciplines are faced with evolutionary problems from physics and medicine, through linguistics, to anthropology and sociology.

Solving the evolutionary problem requires an inter- and transdisciplinary approach, accordingly the modern synthesis includes drift theory, symbiogenesis, lateral gene transfer, hydrization, epigenetics and punctuated equilibrium theory (the idea, called punctuated equilibrium, was originally developed by paleontologists to explain patterns in the emergence and diversification of new species, which sometimes seems to happen in sudden bursts of activity after eons of stability).

Interdisciplinary evolutionary research aims to provide a scientific platform for the growing demand for examining specific evolutionary problems from a multidisciplinary perspective. They do not adhere to one specific academic field, one specific school of thought, or one specific evolutionary theory, but analyze how different evolutionary fields and evolutionary theories provide insight into specific, well-defined evolutionary problems of life and the socio-cultural realm.

Evolutionary theory has been accepted with varying degrees of controversy and consensus in a wide range of disciplines. From biology and anthropology, to medicine, psychology, economics (finance), sustainability science, computer science, and many others, scientists across academia have used the fundamental concepts of heritable variation and selection to understand change in the natural and social world.

Today, finances are crucial to our individual and collective lives and profoundly affect several dimensions of our education and work life to our psychological, ethical, epistemic well-being. The multidimensional nature of finance requires a re-examination of its role not only in theory and practice, but also in society and culture in order to better understand and manage it. Such a re-examination requires a new look at theories of finance and stock markets - a look that is philosophical in nature, since philosophy can enable us to conduct proper and fruitful multidimensional research.

The relationship between philosophy and economics (finance) influenced the evolution of both disciplines. On the one hand, economics makes a constant contribution to philosophy. Thus, the economic concepts of rationality and choice have a profound influence on philosophy of mind and cognitive science (Ross, 2005). On the other hand, economics was born from philosophy (Nussbaum). Nevertheless, the marginalist revolution (Walras, 1900) and the rise of neoclassical economics produced the familiar gradual departure of economics from philosophy. Nussbaum considers this departure to be one of the main reasons for the lack of real intellectual progress in economics.

One of the main functions of philosophy is to create new theories or approaches, as the naturalistic approach à la Dewey-Cellucci claims, and philosophy has already shown its power in this sense. Three examples in finance are performative theory, reflexivity theory, and cryptocurrency theories.

Performative theory is a prototype of the fruitfulness of a philosophical approach to economic and financial issues. This theory is the result of the "journey" of the concept of performativity, which began with the philosophy of language (Austin, 1962; Searle, 1969) and ended up permeating finance (McKenzie, 2006) via anthropology (Butler, 1990) and sociology (Callon, 1998; Latour, 2005). The original philosophical question, that is, the power of language to change the world, is gradually transferred to economics and finance to examine how the theoretical device used to describe the target system (the Model) is transformed into a way of changing it.

The stock market can perhaps be described as a vast, nebulous force that is difficult to comprehend. However, these markets had humble beginnings in Western Europe in 1600. It is necessary to understand the history of the stock market from then to now, in order to understand the digital place where transactions are made with the role of artificial intelligence.

The history of the stock market from 1400 to 2008 (great crisis).

• At the end of the 1400s: Antwerp, or today's Belgium, becomes the center of international trade. Merchants buy goods expecting the prices to rise in order to claim a profit. There is also some bond trading.

• 1611: The first modern stock exchange was created in Amsterdam. The Dutch East India Company was the first company to be publicly traded, and for many years the only company with trading activities on the stock exchange.

• Late 1700s: A small group of traders made the Buttonwood Tree Agreement. Men meet daily to buy and sell stocks and bonds, a practice that eventually led to the formation of the New York Stock Exchange.

• 1790: The Philadelphia Stock Exchange was formed, helping to stimulate the development of the American financial sector and the country's westward expansion.

• 1896: The Dow Jones Industrial Average was created. Initially there are 12 components which were mainly industrial companies.

• 1923: An early version of the S&P 500 was created by Henry Barnum Poor's, Poor's Publishing. It begins by following 90 stocks in 1926.

• 1929: The US stock market crashed after the decade-long "Roaring 20s", when speculators bet bullion on the stock market, inflating prices.

• 1941: Standard & Poor's was founded when Poor's Publishing merged with Standard Statistics.

• 1971: Trading begins on another American stock exchange, the National Association of Automated Quotations of Securities Dealers, otherwise known as NASDAQ.

• 1987: Corporate buyouts and portfolio insurance helped push market prices up until October 19, which became known as "Black Monday."

• 2008: The stock market crashes after the housing boom and bust, along with the spread of mortgage-backed securities in the financial sector.

Today, we can hardly imagine transactions taking place without computers or data science. Science in physics, biology, neuroscience, quantum computers and the Internet have completely changed the game. We are in an algorithmic or automated trading age.

The age of algorithm or automated trading - where computers are programmed to trade independently when certain criteria are met. This made it possible to execute complex trading strategies with the highest precision. Investors and brokers have gained the ability to plan their strategies many moves in advance. They could also hedge against downside risk using automated stop loss orders.

New trading systems have also provided a number of useful algorithmic trading tools. They took automated trading to the next level by allowing computers to trade based on various price signals analyzed in real time. And since computers can execute an almost unlimited number of trades in an instant, high-frequency trading to take advantage of every minute price movement has become the norm.

The development of stock markets around the world shows that the entire stock market is highly dependent on technology, and the evolution is not slowing down.

Stock markets are the driving force behind the creation of national capital. They are a barometer of its economic strength. The development of stock markets has been an eventful journey from a physical market to a market with sophisticated algorithmic trading.

"Many traders have a deep understanding of how markets work but may not understand the tools they are using, in particular the models their computer systems are using."

We could describe the beginning of mathematical financial modeling as cross-pollination with physics. The financial modeling model was developed by the French mathematician and mathematical physicist Louis L.Bachelier (mathematician, March 29, 1900, is considered by many to be the day mathematical finance was born. On that day a French doctoral student, Louis Bachelier, successfully defended his thesis Théorie de la Spéculation at the Sorbonne, in 1900., Bachelier's thesis is a remarkable document on two counts. In mathematical terms Bachelier's achievement was to introduce many of the concepts of what is now known as stochastic analysis. His purpose, however, was to give a theory for the valuation of financial options. He came up with a formula that is both correct on its own terms and surprisingly close to the Nobel Prize-winning solution to the option pricing problem by Fischer Black, Myron Scholes, and Robert Merton in 1973, the first decisive advance since 1900, The economic side of Bachelier's work was ignored until its rediscovery by financial economists more than fifty years later. The results were spectacular: within twenty-five years the whole theory was worked out, and a multibillion-dollar global industry of option trading had emerged). He approached the problem as a willingness to pay for an option - an option is a contract that gives us the right, but not the obligation, to buy or sell a security in the future at a price that we determine in advance at purchase option. Bachelier had the idea that some basic statistical reasoning about probabilities should be used to determine how much the option should be worth. That is, how its value should change over time. He developed a connection between option pricing and certain ideas in statistical physics, especially thermodynamics).

Briefly L.Bachelier was far ahead of his time, half a century passed before he was recognized. In the 1950s, the great economist Paul Samuelson worked on the same type of problem that interested Bachelier. Bachelier's basic presentation was identical to what Samuelson was working on. Thus, the kind of methods that Bachelier had initiated half a century earlier became generally recognized and relevant to financial economists.

In the 1960s, Samuelson and other mathematicians and physicists developed the importance of a certain type of mathematical reasoning in finance. Osborne and Thorp, rediscovered some of Bachelier's ideas and expanded them. Thorp was the first to understand how to take these abstract ideas and use them to make money. In the late 1960s, he launched what is considered the first modern quantitative hedge fund. However, like Bachelier, he too was ahead of his time. He wrote the book Beat the Market, but the book did not attract attention. Only when the ideas of Bachelier, Samuelson and Thorp, along with the economist Myron Scholes and the mathematician (who also became an economist) Fischer Black, did the banks recognize their role and importance in real time. The Black-Scholes document that was published was in 1973 when the first American options exchange opened in Chicago. The Black-Scholes work showed how ideas developed in mathematics and physics could be applied to understanding option pricing. From that point on, things really picked up.

On the one hand, we have the reliability and value of mathematical models and the methodology used to construct mathematical models in finance. On the other hand, we have a completely separate issue of how these models are used (much of what happened in 2007/2008). Especially in the case of mortgage-backed securities, it had more to do with the misapplication of the models than with the failure of the models themselves.

One of the most important concepts in modern financial theory when Fisher Black and Myron Scholes derived a differential equation to solve the price of options, which resembled the heat equation (Rubash). Namely, an option is basically just a contract that legally gives the owner of the contract the option to buy or sell shares,

if it reaches a predetermined price (strike price) before the specified date in the contract, known as "call" and "put", respectively. Due to the risky nature of the option, the buyer of the contract pays at a premium, which is why there is a need for models that can price the option.

Many traders may have a deep understanding and intuition about how the market works, but they may not fully understand all the tools they use, especially some of the models their computer systems use. Because of this, they cannot recognize situations where the assumptions underlying the models make them less reliable. But in many fields, not just finance, there are many people in jobs who don't understand the wider ramifications of what they do. Arguably, the inability to see the long-term consequences of our specific actions should not separate finance from, say, politics or other forms of business.

Contemporary stock pricing approaches in quantitative finance are usually based on the Black-Scholes model and the underlying random walk hypothesis. Empirical data indicate that this hypothesis works well in stable situations, but in sudden transitions, such as an economic crisis, the random walk model fails and alternative descriptions are needed. For this reason, several proposals based on the quantum mechanics formalism have been forwarded, such as the application of the SCoP formalism. It was developed to provide the operational foundations of quantum mechanics, on the stock market. Namely, the stock market is essentially a contextual system in which agents & apos , where global decisions affect the market system and stock prices, which determines non-classical behavior. More specifically, a particular stock does not generally have a specific value (price), but its value is actualized as a consequence of contextual interactions in the trading process. This contextual influence is responsible for the non-Kolmogorov quantum behavior of the market at the statistical level.

The financial world in the embrace of artificial intelligence and the distributed game of neurons

If we get closer to the understanding and deep analyzes of Michio Kaku (theoretical physicist) how to understand the world and think about the world tomorrow we need to learn physics. " To understand economics, you have to understand where wealth comes from. If you talk to an economist, an economist might say: wealth comes from printing money, a politician might say: wealth comes from taxes, I think they're all wrong - society's wealth comes from physics .

All three great revolutions in the past came from physics. Namely, physicists worked out the laws of thermodynamics (1800), which gave rise to the industrial revolution, the steam engine and the age of machines. It was one of the greatest revolutions in human history. Physicists solved the mystery of electricity and magnetism, which gave us the electrical revolution of dynamos, generators, radio and television, and then the laws of quantum theory, which gave us the transistor, computers, the Internet, and the laser. Now we are talking about how physics creates the fourth great revolution at the molecular level: artificial intelligence, nanotechnology and biotechnology. It is the fourth wave, but we can also see the outlines of the fifth wave behind it. This is driven by physics at the atomic level, quantum computers, fusion power and brain-net (when the human mind is connected to computers). So when you look towards the middle of the century, we will be in the fifth wave, and what is driving all these waves? Physics. And how does it manifest itself? Through the economy.

So taxes and money printing are not the source of wealth. These things massage, distribute and manipulate wealth, but do not create it. Wealth comes from physics.

The many aspects of artificial intelligence—from machine learning and virtual reality, to deep learning and neural networks—are becoming strongly intertwined in physics, whether using AI to build better physics or using physics to build better AI. There are countless new research papers on the subject, from applications of machine learning in material detection to a host of applications in medical imaging and diagnostics. As we are (almost) poised on the brink of the quantum computing revolution, the one with artificial intelligence is (almost) already here, with all its possibilities and obstacles. But perhaps what we don't talk about is the enormous impact this ultra-modern technology will have on human relationships, which are often dominated by feelings rather than cold, hard logic.

We are heading towards perfect capitalism, where middlemen, in order to survive, must sell intellectual capital. We are making the transition from commodity capital to intellectual capital. It's a big transition in the market. Commodity capital includes oil and gold, but that is the wealth of the past. Therefore, „today's big billionaires aren't making their billions on gold - they're making it on data because that's the new wealth of the future. „The big billionaires today don't make their billions on gold – they make it on data because that's the new wealth of the future." (M. Kaku, 2022).

How does physics create wealth? By creating two important things: energy and information. Physicists are masters of both because they have created new forms of energy and information.

Artificial Intelligence (AI) is an entry into the complex and intriguing field of human current evolution with learnings and mathematical modeling that is rapidly transforming the global financial services industry in the finance segment. A group of related technologies include machine learning (ML) and deep learning (DL). The potential of AI to disrupt and improve the existing financial services industry. We begin the intellectual journey about artificial intelligence with a deeper insight into neural networks, and quantum computing (QC), and links of artificial neural networks in the field of finance as a partnership with neuroscience, but also the application of deep neural networks in the stock market. The term "artificial intelligence" was coined in 1956 by John McCarthy, and two definitions of AI should also be distinguished, such as the Oxford Dictionary, which defines artificial intelligence as "the theory and development of computer systems capable of normally performing tasks that require human intelligence, such as visual perception, speech recognition, decision-making and translation between languages", and the 6FSB (2017) definition that defines artificial intelligence: "The theory and development of computer systems capable of performing tasks that traditionally required human intelligence." Both are quite broad definitions.

For a moment, let's go back to the thoughts of M. Kak in order to better understand the world around us "what are neural networks?

Artificial intelligence learns to interact with the world the way humans do. Is this five wave ever going to happen?

By the middle of the century, we should have a working fusion reactor and a working quantum computer entering the market. Brain-net will take a few more decades to take off, but investors are already jumping on board. I disagree with most futurists. Most will say that technology is morally neutral - the hammer is morally neutral, the sword can cut against your enemy or against you. Most futurologists will say that there is no moral direction. I wouldn't agree. Because of computers and the Internet, there is a moral direction as the Internet spreads information, spreading empowerment. People are realizing that they don't have to live like this. Why would they tolerate a dictator? Or poverty? When other countries address and resolve these issues, it encourages people in poor countries to promote democracy. So the democratization of the planet is driven by the internet, good or bad (there are bad aspects to it, of course). But there is a moral direction. When the brain-net appears, you can feel the joy and suffering of other people and realize that they are not faking it. If they suffer, there is a reason for it, and people can share this common experience, which will bring us closer together. When I was a kid, I learned something called "Asiatic Sick." I was told that China and India will be eternally poor because of their huge populations. But today we learn that China and India may become superpowers in the future. What happened? An ignorant, uneducated peasant is indeed a burden to society, but once educated, he can change the fate of the world."

While, Kaplan (2016) describes AI as, "The essence of AI, indeed the essence of intelligence, is the ability to make appropriate generalizations in a timely fashion based on limited data. The broader the domain of application, the quicker the conclusions are drawn with minimal information, the more intelligent the behavior." With the global growth of the artificial intelligence industry, how AI is changing the financial services industry, or D.E. Shaw, 1996 who says that "Finance is really a wonderfully pure information-processing business." Fraud detection and compliance, Banking chatbots and robo-advisory services, . Algorithmic trading, other applications of AI, "Machine learning promises to shake up large swathes of finance." , but on artificial neural networks.

Altman et al. (1994) compare artificial neural networks (ANN) with traditional statistical methodologies including logit analysis and discriminant analysis. They analyze the financial condition of 1,000 Italian

industrial companies between 1982 and 1992 and find that NNs show acceptable classification and retention of sample accuracy. Using S&P data between 1970 and 1989, Coats and Fant (1999) find that NNs are more effective than MDAs for early detection of financial distress and identifying firms that receive going concern opinions. Other works showing that NN techniques are at least as good as MDA methods include: Williams (1985); Odom and Sharda (1990); Utans and Moody (1991) when applied to bond rating forecasts. NN performs well given the limited availability of data and the lack of complete a priori information that could be used to impose structure on the network architecture. Garavaglia (1991) looks at bond prices using NN. Salchenberger et al. (1992) compare NN with MDA techniques using parsimonious failure applications. They believe that NN requires fewer assumptions and achieves a higher degree of prediction, accuracy and is more robust than traditional statistical methods. Tam, K.Y. and Kiang, M.Y. (1992) compare NN methods with linear classifiers and logistic regression applying Texan bankruptcies (Tam, K. Y., & Kiang, M. Y. (1992). Managerial applications of neural networks: the case of bank failure predictions. Management science, 38(7), 926-947.)

Angelini et al. (2008) apply NN to a credit risk model for Italian SMEs and find that NN methods work very well. Hutchinson et al. (1994) use the NN algorithm and consider it a framework for modeling option pricing functions. Amilon (2003) uses daily call option price data to test whether NN can outperform the Black-Scholes formula. NNs are applied to out-of-sample pricing and delta hedging, and Amilon (2003) finds NNs outperform the Black-Scholes formula in both hedging and pricing. Culkin and Das (2017) use a fully connected DL NN to reproduce the Black and Scholes (1973) option pricing formula. First, Culkin and Das (2017) begin by applying learning the BlackScholes option pricing model from simulated data. The next step is to use the market data to train an option pricing model that performs better in terms of predictive accuracy, adaptability and robustness, which is their main result. This is achieved with a high degree of accuracy. Li et al. (2018) employ DL—specifically, a method that uses layers of ANNs to automatically process earnings calls and assess the cultural value of companies.

Their ML approach provides a culture dictionary useful for measuring corporate culture that is also scalable to a large collection of textual data. Quantum computing (QC) is a relatively new field of research that studies algorithms and systems that apply quantum phenomena to complex problems. QC can potentially process data at a speed that is impossible with traditional computers. Traditional computers process information only in binary format, in zeros or ones. Benioff and Feynman founded this field in the early 1980s and recorded it. Digital computers (DCs) cannot effectively simulate a probabilistic system, but QC can. QCs are much more suitable than DCs for solving financial problems acting on random variables, while DCs only simulate random variables. QC can hold multiple states simultaneously coexisting states or qubits. Qubits can process four values at any time and allow a computer to process information in parallel (future today Institute, 2017). Qubits are memory elements that can contain a linear superposition of both states and are a game changer for the financial services industry. Application security is defined as the set of steps a developer takes to identify, fix, and prevent security vulnerabilities in applications at multiple stages of the software development lifecycle. Rolling IT security is one of the most famous applications of QC. Rosenberg et al. (2015) apply QC to portfolio optimization problems. Lopez de Prado (2016) suggests that QC has potential with financial problems involving scenario analysis or option pricing. In the case of scenario analysis, QC can evaluate an extremely large number of outcomes that could be generated randomly, and for option pricing, QC can evaluate a large number of paths that can be computationally expensive. ML is expected to have a far stronger impact when combined with QC capabilities. Lopez de Prado (2016) describes how QC has the potential to improve clustering algorithms more efficiently.

High Frequency Trading (HFT) is complex algorithmic trading in which a large number of orders are executed within a few seconds. It adds liquidity to the markets and allows an incredible amount of money to flow through it every split second.

HFT depends on quick reactions to meaningful information. A typical algorithm in high-frequency trading operates on a millisecond time scale. In this type of trading, an investor's success is not only based on the quality of information used to support decision making, but also depends on how quickly decisions are made. An approach commonly used to predict the future price of stocks and help make profitable short-term trading decisions is technical analysis: treating the stock's historical behavior as a time series (J. J. Murphy, 1999).

The ability to accurately and quickly predict stock price movements is the key to profitability in high-frequency trading. Forecasting stock movements is important in the financial world because investors want to observe stock price trends before making investment decisions. But considering nonlinear non-stationary financial time series of stock price characteristics, we are faced with the application of Wavelet mathematical function, because Wavelet analysis has good time-frequency local characteristics as well as good zooming ability for non-stationary random signals. But there is an application of wave theory that is limited to a small scale, that is why the method of neural networks is a powerful tool for large scale problems. Thus, the combination of neural networks and wavelet analysis is more applicable for stock behavior predictions. However, it should be emphasized, dealing with nonlinear, non-stationary and large-scale financial features of time series is still a difficult task, because it is difficult to illustrate the stock market, which is an inherently unstable, complex and nonlinear system (Chen, Y.; Hao, Y. A, 2022). We must also include the influence of politics, and various other factors that interfere with easier measurements or calculations. They could conclude with the quote ""The rise of powerful AI will be either the best or the worst thing ever to happen to humanity. We do not yet know which." Stephen Hawking.

Science has always followed the natural rhythm of alternating phases of expansion and concentration. Times of unstructured research were followed by periods of consolidation, grounding of new knowledge in fundamental concepts. We can hope that the current period of tinkering with artificial intelligence, quantum devices and genetic editing, with its many useful applications, will eventually lead to a deeper understanding of the world and the multidimensional nature of finance.

Let's open the door to imagination and knowledge to our inner Universe. Is artificial intelligence the new alchemy? Is that bad? With so many opportunities to explore new configurations of matter and information, we could enter a golden age of modern-day alchemy.

If we imagine that knowledge flows downstream, from the source of an abstract idea, through twists and turns of experimentation, to a wide delta of practical applications, then we arrive at the famous notion of the "utility of useless knowledge," which Abraham Flexner put forward in his 1939 essay. A canonical illustration of this flow is Albert Einstein's general theory of relativity. The laws of physics apply to all observers, regardless of their motion. Albert Einstein translated this concept into the mathematical language of curved space-time and applied it to the force of gravity and the evolution of the cosmos. Without Einstein's theory, the GPS in our smartphones would be off course by about 7 miles a day.

But perhaps this paradigm of the usefulness of useless knowledge is what the Danish physicist Niels Bohr liked to call "the great truth"—a truth whose opposite is also a great truth. Perhaps, as AI shows, knowledge can also flow uphill.

In the broad history of science, as LeCun suggested, we can observe many examples of this effect, which may perhaps be called "the uselessness of useful knowledge." A comprehensive and fundamentally important idea can emerge from a long series of step-by-step improvements and playful experimentation—say, from Fröbel to Nobel.

The best illustration is the discovery of the laws of thermodynamics as the cornerstone of all branches of science. These elegant equations, which describe the conservation of energy and the increase of entropy, are natural laws that all physical phenomena obey. But these universal concepts only became apparent after a long period of experimentation, starting with the construction of the first steam engines in the 18th century and the gradual improvement of their design. This is how mathematical laws slowly appeared.

However, after this walk, let's return to the links of artificial neural networks in the field of finance.

Artificial neural networks provide clues as to how the brain learns. Neuron expressions can mimic a known AI learning strategy. Backpropagation alone is not biologically plausible because, among other things, real neurons can't simply stop processing the outside world and wait for backpropagation to begin—if it did, we'd end up with lapses in vision or hearing.

Naud and Richards' new model circumvented this by simply changing the canonical understanding of how neurons communicate with each other. We know that neurons behave like bits, capable of only two outputs, either they send a spike of electrical activity to another neuron or they don't (either 1 or 0). But it is true that

neurons can send a "burst" of spikes in rapid succession. This has been shown to change the connections between neurons, making bursts a natural candidate for solving the credit assignment problem. In the new model, the neuron fires a third output signal, stream 1 so close to one to the other that it actually becomes 2. rather than encoding anything about the outside world, 2 acts as a "teaching signal" that tells other neurons whether to strengthen or weaken their interconnections, based on the error made at the top of the circuit.

But for this teaching signal to solve the problem of scoring without a "pause" in sensory processing, their model required one key piece. Namely, Richard Naud and Blake Richards' team proposed that neurons have separate compartments at the top and bottom that process the neural code in completely different ways. Therefore, their model shows "that it can really have two signals, one going up and the other down, and they can pass each other" (Naud, 2021). Their model assumes that tree-like branches that receive inputs at the tips of neurons listen only to bursts—an internal learning signal—to adjust their connections and reduce error. Tuning happens from the top down, just like in back propagation, because in their model the neurons at the top regulate the probability that the neurons below them will send a burst. The researchers showed that when the network has more bursts, neurons tend to increase the strength of their connections, while the strength of connections tends to decrease when burst signals are less frequent. The idea is that the burst signal tells neurons that they should be active during the task, strengthening their connections, if this reduces error. The absence of bursts tells neurons that they should be inactive and may need to weaken their connections.

At the same time, the branches at the base of the neuron treat the bursts as if they were individual spikes—a normal signal from the outside world—allowing them to continue sending sensory information upward in a circuit without interruption.

"In retrospect, the idea presented seems logical and I think that speaks to its beauty," (João Sacramento, computational neuroscientist at the University of Zurich and ETH Zurich). "I think it's brilliant."

Others have tried to follow a similar logic in the past. Twenty years ago, Konrad Kording of the University of Pennsylvania and Peter König of the University of Osnabrück in Germany proposed a two-compartment neuron learning framework. But their proposal lacked many of the specific details in the newer model that are biologically relevant, and it was just a proposal—they couldn't prove that it could actually solve the credit allocation problem.

With today's computing power, Naud, Richards, and their colleagues successfully simulated their model, with scattered neurons playing the role of learning rules. They show that it solves the credit assignment problem in a classic task known as XOR, which requires learning to respond when one of two inputs (but not both) equals 1. They also show that a deep neural network built with their bursting rule can approximate the performance of the backpropagation algorithm to challenging image classification tasks. But there is still room for improvement, as the back-propagation algorithm is still more accurate, and none fully matches human capabilities.

"There have to be details that we don't have, and we have to make the model better," stressed Naud. "The main goal of the paper is to say that the kind of learning that machines perform can be approximated by physiological processes."

In this way, AI researchers can discover the ways in which the brain converges, as backpropagation could ultimately improve the way AI systems learn. "If we understand this, it could eventually lead to systems that can solve computational problems as efficiently as the brain does" (Marcel van Gerven, chair of the artificial intelligence department at the Donders Institute at Radboud University in the Netherlands).

The new model suggests that a partnership between neuroscience and artificial intelligence could go beyond our understanding of each and instead find the general principles necessary for brains and machines to learn anything at all.

Artificial intelligence is considered the commanding point of science and technology in today's time. In the financial industry, the application of AI technology in risk control, marketing, customer service, transactions, operation and product optimization of financial institutions is becoming a lever for partnership with

neuroscience. Some new business models were also created. Starting from the application status and significance of artificial intelligence in the international financial field.

The new learning model focuses on bursts of neural activity that act as teaching signals - approximating backpropagation, the algorithm behind learning in AI.

Every time a human or a machine learns how to improve at a task, a trail of evidence is left behind. A sequence of physical changes - cells in the brain or numerical values in an algorithm - is the basis of improved performance. But how the system needs to figure out exactly what changes to make is a big deal. It is a credit assignment problem, in which a brain or artificial intelligence system must determine exactly which parts of its system are responsible for errors and then make the necessary changes. So it's a blame game.

Artificial intelligence engineers solved the machine credit problem with a powerful algorithm called backpropagation, popularized in 1986 by the work of Geoffrey Hinton, David Rumelhart, and Ronald Williams. It's the workhorse that drives learning in the most successful artificial intelligence systems, known as deep neural networks, which have hidden layers of artificial "neurons" between their input and output layers.

A team of researchers led by Richard Naud of the University of Ottawa and Blake Richards of McGill University and the Mila AI Institute in Quebec have discovered a new brain learning algorithm model that can mimic the backpropagation process. It's so realistic that they've encouraged neuroscientists to study actual neurons to find out if this is what the brain actually does. "Ideas that come from a more theoretical side can drive incentives to do experiments, and for my money this paper crosses the line," said Matthew Larkum, an experimental neuroscientist at Humboldt University in Berlin. "It's biologically plausible and could have big consequences.

However, these two processes are not exactly the same. When a deep neural network is trained to recognize an image, it takes place in two stages: first forward propagation and then back propagation, when "learning" occurs. During the first phase, neurons in the input layer encode the features of the image and pass it on. Then the neurons in the hidden layers perform calculations and send their results to the output layer, which spits out its image prediction, like a "cat". But if the image is actually a dog, then it's up to the backpropagation algorithm to step in and fix what went wrong by adjusting the weights that connect the neurons.

These changes are based on calculating how each neuron can contribute less to the overall error, starting with the neurons at the top, closest to the output layer, and then moving backwards through each layer. If the backpropagation algorithm estimates that increasing the activity of a particular neuron will improve the output prediction, then the weights of that neuron will be increased. The goal is to change all the connections in the neural network - each one a little in the right direction - until the output predictions are correct.

For decades, researchers have been trying to figure out how the brain might perform something like backpropagation to solve the problem of assigning points.

Quantum and relativist theory and modern financial markets

Richard Feynman once said, "Nature isn't classical, dammit, and if you want to make a simulation of nature, you'd better make it quantum mechanical, and by golly it's a wonderful problem, because it doesn't look so easy ."

Diving into the concept of 'quantum potential' is a fundamental part of the structure of Bohm's mechanics (Holland P.), known as the semi-classical approach to quantum mechanics. Involving the concept of quantum potential in an interdisciplinary context can lead to ambiguity and requires innovative interpretation. The quantum potential is derived from the Schrödinger PDE by substituting the wave function ψ in its polar form, ReiS. Essentially, one first substitutes the polar form in the first partial time derivative of ψ (the left-hand side of the Schrödinger PDE). It then continues with the replacement of the polar form into the second partial positional derivative of ψ, which together with the multiplication of the real potential and the wave function forms the right side of the Schrödinger PDE.

Quantum finance theory using the quantum anharmonic oscillator model begins with the concept of quantum financial particles (QFP) and their intrinsic quantum energy fields, let's call them the quantum price field (QPF). So, he studies quantum prices in quantum finance and its relationship with the quantum energy level. It then examines the Schrödinger equation but also explores the physical meaning of the wave function (ψ), leading to five key players in secondary financial markets – market makers, arbitrageurs, speculators, hedgers and investors, including their roles, characteristics and behaviours, and study and research classical financial dynamics and the concept of excess demand. Based on the definition of excess demand, Schrödinger derives the quantum dynamics of these five key parties and derives an overall quantum dynamic equation for their combined behavior in the secondary financial market. The Schrödinger equation will then be revisited and combined with the author's latest work on modeling the quantum dynamics of various parties in the secondary financial market, together with a step-by-step mathematical derivation of the Schrödinger equation of quantum finance.

We explore the foundations of quantum finance through the five basic laws of the dynamics of the world we live in from three different perspectives, from the macroscopic world of general relativity to the microscopic world of quantum mechanics.

Properties and features of quantum mechanics include quantization, wave-particle duality, and Heisenberg's uncertainty principle, how these unique and extraordinary quantum phenomena are related and observed in real-world financial markets provide the motivation for the development of quantum finance models. The core framework integrates the core model of the quantum financial system with modern artificial intelligence technology such as neural networks.

Quantum finance is a new field that seeks to solve the problems that arise with the standard model (money is real and takes the form of cash and assets).

The brilliance of the bead, so to speak, arose as a result of a discussion between a CERN experimental physicist and his private banker in Geneva. This led to a collaboration between CERN and a select group of Swiss bankers, who between them created a discrete GW (Gnomes and Wizards).

The motives of the CERN researchers were a combination of the simple pure pursuit of knowledge and the hope that a successful predictive theory would solve their perennial funding problems. The bankers suffered from their twin emotions of fear and greed. The fear that they might lose if Quantum Finance works, and they didn't know about it, and the greed that made them hope for an advantage.

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It was originally believed that cash was invented by the ancient Greeks, with the rationale that Aristotle was quoted as saying "all investment advisors are sophists". More recent studies have concluded that the Greeks got their ideas from the ancient Egyptians, who until then were only credited with inventing the sale of pyramids.

For years, cash was used in ignorance of its true nature, and economic activity was slow, with takeover techniques limited to rape and robbery, and widespread protectionism that was little more than a protection racket (Danegeld).

The period ended with the development of Banks, who managed to identify some fundamental monetary laws, and develop some sophisticated tools for financial analysis comparable to the development of Log in the field of mathematics.

Profits/losses/cash flows and interest, the foundations of classical monetary theory were laid and codified (or used) by Adam Smith (Venice and Lombardi) which eventually led to the creation of the gold standard. While another group, which first noted the relationship between mathematics and money, invented actuarial studies and then insurance.

This edifice lasted until the 1970s when its increasing complexity (analogous to the construction of larger particle accelerators) revealed cracks in the classical theory, although no one noticed at the time.

Key areas were OPEC price increases and the subsequent recycling of petro dollars to the third world in the belief that no country could fail. This turned out to be an illusion that can only be solved by applying a quantum approach to money. Another feature of this period is the emergence of derivatives (swaps, futures, options) that seemed to obey their own rules and had even less of a relationship with real money than was normal.

Finally, it was realized that the world's assets are much smaller than the world's money supply, and that most money does not refer to property, gold, goods, services or any other clear source, but to something intangible, called "trust", which is considered, may be a cousin of the Higgs boson.

It was clear that only quantum and relativistic theory could explain reality as examined by modern financial markets.

While everyday concepts like cash, profit and loss apply in the ordinary world (quantum money and the absence of "real" money and duality), they break down in extremes (which is why seemingly healthy institutions like Barings or Orange County can collapse so suddenly). In reality, the true elements of money can never be seen, but only followed by their effects or symbols.

We cannot know both the ownership of the property and its value (Principle of Uncertainty of Real Estate Brokers). If we know who owns it, then we don't know its value. We know its value only at the time of sale, that is, when it is between owners.

Schrodinger (Schrodinger's bank account), in addition to having a cat, (whether alive or dead) also had a bank account, which he was equally insecure about. The reason is that the bank is nothing more than a wave of financial probability, and he could only know that his money was safe when he asked for it back. At this point the wave collapses into "solvent" or "insolvent" and he can withdraw his money or not. (of course, once he held the cash, he was hardly happier because the value of the cash was a function of the waveform of the countries' probabilities.).

Bill, Schrodinger's brother, is believed to have failed after lending money on the grounds that the waveform had to eventually collapse as "insolvent", leaving him with no creditors. He was of course right in his fundamental understanding, but wrong in his probability calculations.

Black Scholes are complex areas of the financial continuum. They turn it around and form the greatest singularity surrounded, everything that falls disappears forever.

There is still a lot of room left in model building.

How big can the quantum world be? Physicists are testing the limits.

A journey through the quantum world about quantum ideas and phenomena is also a description of many mind-boggling phenomena, such as a quantum object that is in two places at once or a certain minus sign that is the most important in the universe. Even large objects can exhibit bizarre quantum behaviors, physicists hope will shed light on the mystery of quantum collapse, identify the quantum nature of gravity, and perhaps even make Schrödinger's cat a reality.

What does quantum theory tell us about reality?

Quantum physics has, on the one hand, changed our theoretical description of the physical world, and on the other, it has revolutionized everyday life, allowing us to build lasers, atomic clocks used in GPS, and semiconductor devices such as laptops and smartphones. Basic principles: superpositions, entanglements, quantum non-locality, decoherence theory and measurements, and some selected applications: quantum cryptography and quantum computers, cold atoms, light and laser diodes and atomic clocks.

Almost a century after its inception, physicists and philosophers still don't know - but they're working on it - it covers a field of physics that is both one of the most powerful, transformative and precise tools for the study of nature, put simply for non-physicists one of the most mysterious and misunderstood aspects of all of

science. Developed at the beginning of the 20th century to solve a crisis in understanding the nature of atoms, quantum mechanics laid the foundation for theoretical and practical advances in 21st century physics. There is a deeper awareness that the nature of particles, waves and their interrelationships provides the basis for today's understanding of the field, and outlines the ways in which that understanding has led to significant applications today.

Hello quantum world! The Mystery of the Quantum World, Philosophical Considerations and Analyzes of Quantum Theory, lucidly outlines the various points of view adopted by various physicists who seek to understand the meaning behind the theories in daily use.

Italian theoretical physicist Carlo Rovelli offers a new way of understanding the world and interpreting quantum theory in his recent book Heligoland, there is the beauty and mystery of the curious human mind. German physicist Werner Heisenberg started a scientific revolution. He first came up with the quantum theory during the summer vacation in 1925, which he spent on a barren island in the North Sea, after which Rovelli's book is named.

The world, Heisenberg thought, cannot be precisely stated, but is only known through models of uncertainty and probability. Received the Nobel Prize in 1932, it was clouded by the tacit support of Nazi Germany. His theory led him to Erwin Schrödinger's "cat in a box" thought experiment. Quantum theory suggested that just by opening the container one could determine whether the cat was dead or alive. If the box remains closed, the unfortunate cat is in limbo – in a state between life and death, a superposition of possibilities.

Professor Rovelli breaks down attempts to remove the indeterminacy of quantum mechanics. First, he takes up the "many worlds" thesis, which claims that every possible alternative exists, and we only see one of them. In short, Schrödinger's cat is alive in one universe and dead in another. Some argue that Heisenberg's work would fail for some as yet undiscovered macroscopic entity. In this explanation, the cat is too big to be subject to quantum physics. More recently, it has been argued that quantum systems have certain properties; we simply do not know enough about these systems to accurately predict their behavior. But in Heligoland it is dismissed as an attempt to return to a pre-1920s look.

Quantum theory observes "the physical world as a network of relationships, objects are its nodes" (Rovelli). In its "relational" interpretation, Schrödinger's cat only has properties when it interacts with something else. When not interacting, it has no properties. Rovelli draws on Buddhist thought to explain his ideas. So, if nothing exists by itself, surely everything exists solely through dependence. "Facts are relative," opens minds to a debate that will probably last longer than the century of arguments it seeks to close.

Physicist Richard Feynman believed that "nobody understands quantum mechanics". That is no longer true. Smartphones, nuclear power plants, medical examinations and laser-operated doors have been built using insights from physics that govern the subatomic level. What confuses many is that the quantum world is governed by rules that contradict classical notions of physical laws.

In quantum mechanics, nature is not deterministic. Subatomic particles do not travel along a path that can be mapped. It is only possible to calculate the probability of finding those spots at a certain point. Physics as a hard science disturbed its greatest minds (although even today physics creatively disturbs the minds of scientists). Albert Einstein thought that the idea that an element of randomness was deep in science was absurd. "God doesn't gamble," he famously declared.

We enter the most beautiful garden of the human mind, the mystery of the quantum world, which various physicists have adopted and strive to understand the meaning behind the theories that are used every day.

From the quantum world, we picked "pricing of financial derivatives with the IBM quantum computer" (research conducted in 2019 and published in 2021 by Ana Martin, Bruno Candelas, Ángel Rodríguez-Rozas, José D. Martín-Guerrero, Xi Chen, Lucas Lamata , Roman Orús, Enrique Solano, Mikel Sanz).

In finance, derivatives are contracts whose value derives from the value of a set of assets, assets, funds, such as indices, bonds, currency exchange rates, shares, market indices, or interest rates. Financial derivative contracts include forward contracts, swaps (currency swaps or interest rate swaps), limits, thresholds and

swaps. They are used for management (mitigation), risk exposure (protection) or for speculation. Determining the prices of interest financial derivatives (assumption of neutral risk, D. Brigo and F. Mercurio; S. E. Shreve) requires precise modeling of the time evolution of interest rates. The literature points us to the way of modeling or the current interest rate r(t) (also known as the current short rate, or as the short rate), i.e. the forward rate, but the forward rate in the future is infinitesimally small, the period (T, T + δt) predicted in the previous time t, denoted by f (t, T). Simple dynamics based on one or two random factors for modeling both short rates and forward rates have been proposed (D. Brigo and F. Mercurio, S. Kogan, D. Levin, B. R. Routledge, J. S. Sagi, and N. A. Smith, S .Lahmiri). For short rates, one-factor and two-factor models are known, such as Model Vasicek, the Hull-White model, the Cox-Ingesroll-Ross (CIR) model and its extension CIR++ as one-factor models, and the Gaussian-Vasicek model and Hull-White model, as a two-factor model.

Their corresponding algorithms are easy to implement. However, there are also shortcomings with these models because the requirements stemming from calibration according to market data and capturing, at the same time, correlation and covariation structures from the time evolution of different forward rates. However, it is possible to overcome these limitations through the Heath-Jarrow-Morton (HJM) framework (D. Heath, R. Jarrow, and A. Morton, Bond; R. Jarrow) directly modeling the time evolution of forward rates. Thus, the HJM model is a general family of models from which forward rates are proposed. Without going into detailed analyzes of the components of quantum principles, quantum circuits, we can summarize the complex proposed approach through the implementation of an effective noise factor algorithm in the current evolution of forward rates according to the Heath-Jarrow-Morton multifactor model. The model considers several noise factors to describe the dynamics of several maturing term rates that can be collected in a cross-correlation matrix. In doing so, the main components were experimentally evaluated using a hybrid quantum algorithm with five-qubits IBMQX2 quantum computer for 2×2 and 3×3 cross-correlation matrices, which are based on historical data.

In fact, the financial services industry is full of potential applications for quantum computing, including optimization, simulation and machine learning. But it is not so easy to determine which applications are most likely to benefit from the quantum advantage and exactly how much quantum computers. An Analysis of Derivatives Pricing Advantage (G.Sachs&IBM), Indicated the "Threshold for Quantum Advantage in Derivatives Pricing," quantum research teams at IBM and Goldman Sachs provide the first detailed estimate of the quantum computing resources required to achieve a quantum advantage for pricing the price of derivatives – one of the most common calculations in finance.

By applying the quantum anharmonic oscillator model, they could start playing with the concept of quantum financial particles (QFP) and their intrinsic quantum energy fields, the quantum price field (QPF). But by exploring the quantum price in quantum finance and its relationship with the quantum energy level, he points to the need to examine the Schrödinger equation and the physical meaning of the wave function (ψ), followed by an exploration of the nucleus of five key players in secondary financial markets: market makers, arbitrageurs, speculators, hedgers and investors, including their roles, characteristics and behaviors.

Quantum computers (and quantum software) are based on a completely different model of how the world works. In classical physics, an object exists in a well-defined state. In the world of quantum mechanics, objects appear in a well-defined state only after we observe them. Prior to our observation, the states of two objects and their relationship are matters of probability. From a computing perspective, this means that data is recorded and stored in a different way - through non-binary qubits of information rather than binary bits, reflecting the multiplicity of states in the quantum world. This multiplicity can enable faster and lower cost computations for combinatorial arithmetic.

Impressive and stunning! Even particle physicists struggle to understand quantum mechanics and the many extraordinary properties of the subatomic world it describes, and this is not the place to attempt a full explanation. But what we can say is that quantum mechanics does a better job of explaining many aspects of the natural world than classical physics and accepts almost all the theories that classical physics has produced.

Quantum, in the world of commercial computing, translates to machines and software that can in principle do many things that classical digital computers can do and also do one big thing that classical computers can't: perform combinatorial calculations quickly. As we describe in our paper, commercial applications of quantum

computing will be a big deal in some important domains. In some cases, the importance of combinatorics is already known to be central to the domain.

Chemical and biological engineering. Chemical and biological engineering involves the discovery and manipulation of molecules. This involves the movement and interaction of subatomic particles. In other words, it involves quantum mechanics. The simulation of quantum mechanics was a key motivation in Richard Feynman's initial proposal to build a quantum computer. As molecules become more complex, the number of possible configurations grows exponentially. This becomes a combinatorial calculation, suitable for a quantum computer. For example, programmable quantum computers have already demonstrated successful simulations of simple chemical reactions, paving the way for increasingly complex chemical simulations in the near future. With the advent of the feasibility of quantum simulations, which help predict the properties of new molecules, engineers will be able to consider configurations of molecules that would otherwise be challenging to model. This capability means that quantum computers will play an important role in accelerating current efforts in materials discovery and drug development.

In Cybersecurity, combinatorics has been central to encryption for over a thousand years. Al-Khalil's Book of Cryptographic Messages from the 8th century dealt with the permutation and combination of words. Today's encryption is still built on combinatorics, emphasizing the assumption that combinatorial computations are essentially unmanageable. With quantum computing, however, cracking encryption becomes much easier, posing a threat to data security. A new industry is growing to help companies prepare for upcoming vulnerabilities in their cybersecurity.

As more people turn their attention to the potential of quantum computing, applications beyond quantum simulation and encryption are emerging:

Artificial Intelligence. Quantum computing potentially opens up new possibilities in artificial intelligence, which often involves combinatorial processing of very large amounts of data in order to make better predictions and decisions (think facial recognition or fraud detection). The growing field of quantum machine learning research identifies ways in which quantum algorithms can enable faster artificial intelligence. The current limitations of technology and software make quantum artificial general intelligence a fairly remote possibility - but it certainly means that thinking machines are more than the stuff of science fiction.

Quantum computing, which solves large-scale combinatorics problems faster and cheaper, has spurred billions of dollars of investment in recent years. The biggest opportunity may be in finding new applications that benefit from the solutions offered through quantum.

"I can calculate the motions of heavenly bodies, but not the madness of people" — Sir Isaac Newton after the South Sea Company bubble crash in 1721.

Using Newton's example as an icon of human reasoning, we can learn that the stock market is ultimately modeled by its participants. Any reasonable investment strategy is vulnerable to the sometimes arbitrary decisions of human beings. In Newton's words, it is not possible to calculate the madness of people.

In the world of quantum computers, these are a new type of hardware that works on the principles of quantum physics. While traditional computers use bits and a binary system to represent information (either zero or one), quantum devices store information in qubits, which can be found in a certain state, a superposition (both zero and one at the same time). This allows them to process a huge amount of information much faster than classic devices. However, quantum hardware technology has yet to be developed; therefore, most of the advantages offered by quantum computers compared to conventional computers are almost entirely theoretical in nature. However, companies in the banking and financial sector are already experimenting with this technology to exploit its potential or take precautions regarding its implications. Banks, hedge funds, asset managers and all types of financial institutions deal with highly sensitive customer data, as well as transaction and contract information. Moreover, regulators require that this data be stored for a period of several years to several decades. Therefore, it is most important that it remains secure and private. Some of the encryption algorithms used today rely on complex mathematical problems that classical computers cannot solve.

"In the Finance sector, which deals with sensitive and private information, our greatest concern is what we call post-quantum cryptography (PQC). This refers to the landscape of privacy, cryptography, and encryption after the day when quantum computers become capable of breaking many of today's encryptions. Post Quantum Cryptography should be something that is on everybody's mind." Peter Bordow, Principal Systems Architect for Advanced Technologies at Wells Fargo.

However, it has been theoretically proven that a quantum computer could break some types of encryption in minutes or seconds, and several algorithms have already been developed that can do this.

Quantum hardware has not yet reached the necessary level of development to run such algorithms. However, as soon as large-scale fault-tolerant universal quantum computers become available, there is a risk that all data and private information about people, companies and transactions will be exposed. Some scientists expect this to happen in the next decade. Based on the "harvest now, decrypt later" principle, nefarious actors are now believed to be hoarding encrypted data with the aim of accessing it as soon as more powerful quantum devices become available.

Therefore, by starting to use quantum-resistant algorithms already at this stage, data owners could protect their data in the future as well.

Optimal arbitrage, credit scoring, derivative pricing, all these financial procedures involve many mathematical calculations and become even more complicated and demanding as the number of variables increases. At some point, people have to settle for less than optimal solutions, as the complexity of the problem exceeds the capabilities of current technology and methods.

These intractable problems (which a traditional computer cannot solve in a reasonable amount of time) represent the best use cases for quantum technology. One of the most valued applications of quantum computing in the financial sector is the accurate simulation of markets and the ability to predict how a change in the price of a commodity will affect the cost of another asset. According to experts in the field, quantum computers should perform so-called Monte Carlo simulations to forecast future markets, predict the price of options or assess risk and uncertainty in financial models. By optimizing machine learning and using algorithms capable of recognizing patterns in large amounts of data, quantum computers can perform these highly complex predictions and predictions.

Trading and portfolio optimization are other areas where quantum computing could significantly help. Considering market volatility, customer preferences, regulations and other constraints, traders are currently limited by computational limitations and transaction costs in simulating a large number of scenarios and improving portfolio diversification. Scientists have already proven that quantum technology can handle the complexity of these problems.

The meeting of physics with financial networks

How to connect physics and the financial system in the field of understanding and acceptance? Principles and techniques derived from physics can be very effective in describing the processes that take place in financial markets. Modeling financial systems as networks can improve our understanding of phenomena that are relevant not only to researchers in economics and other disciplines but also to public agencies and governments. Complex network theory provides a powerful framework for studying the propagation of shocks in financial systems, identifying early warning signals of impending crises, and reconstructing hidden connections in interbank systems. Economists try to predict financial crises, and physicists want to understand systems containing many particles. Both problems are very challenging. However, researchers need to understand the system without complete information. Even if they have all the information, complex systems are still difficult to understand because of the many connections between components. These problems are faced by a wide range of scientific disciplines.

The total value of the global financial market has exceeded the value of the real economy, financial institutions have created a global network of interactions that embodies systemic risks. Understanding networks requires new theoretical approaches and new tools for quantitative analysis. Statistical physics has significantly developed new metrics and models for studying financial network structure, dynamics, and stability and instability.

Financial institutions are interconnected in a global network of interactions whose structure can be quantitatively analyzed using network theory, a framework that studies the structure and consequences of relationships that connect different objects in large systems. Namely, the financial system can be viewed as a network whose nodes represent agents (retail and investment banks, insurance companies, investment funds, central banks, but also non-financial companies and households) and whose edges represent dependencies between nodes.

Thus, the financial system consists of financial actors (institutions such as banks or pension funds, but also small "fintech" companies or households), markets (shares or bond markets), contracts (ownership of shares, or a loan between two banks, or from banks to companies, or from banks to households) and regulatory authorities (financial supervisors and central banks). The network is a natural description of the financial system. Nodes represent financial actors, and links can represent contracts or other types of relationships (two actors investing in the same asset). There are processes that take place on the financial network, where the properties of the nodes change, but the connection remains the same, such as the flow of income from economic activities to the owners of the corresponding securities or the spread of losses. In the financial network, relationships change over time. The result is a description of a financial system that requires a time multiplex network, where each layer is associated with a certain type of relationship (interbank loans of a certain maturity). The resulting macroscopic properties of the network are then important for understanding issues of general interest such as the conditions for financial stability or a smooth transition to a low-carbon economy. But the structure of financial networks also develops as a result of actors' attempts to predict the future of the network itself in competition with other nodes. The feedback loop makes investigating financial networks a scientific challenge that is fundamentally different from network-related questions in the natural sciences.

Mapping networks in terms of nodes, links and physical analogs emphasize similarities and differences with others related to other areas of physics, such as contact processes (Castellano, C. & Pastor-Satorras, R) diffusion theory (Masuda, N., Porter, M. A. & Lambiotte, R.) and epidemics (Pastor-Satorras, R., Castellano, C., Van Mieghem, P. & Vespignani, A.) and single-layer networks. While economic networks comprise several types of relationships, such as lending or the supply of goods and services, the ownership network best reflects the power relations (Hill, J. G. & Thomas, R. S.; Corrado, R. & Zollo, M.) of economic and financial actors.

The global ownership network is highly resilient in terms of power structure as well as the events of the 2008 financial crisis (Glattfelder, J. B. & Battiston, S.). But initially only static ones were available for individual countries. The analyzes showed that empirical works analyzed interbank networks in several countries (Austria, Boss, M., Elsinger, H., Summer, M. & Thurner, S. and USA, Soramäki, K., Bech, M. L., Arnold, J ., Glass, R. J. & Beyeler, W. E.) paved the way for a series of papers covering : Brazil, Cajueiro, D. O. & Tabak, B. M. ; Santos, E. B. & Cont, R., Belgium, Degryse, H., Nguyen, G.et al., Colombia, León, C. & Berndsen, R. J .Germany, Craig, B. & Von Peter, G., Italy, De Masi, G., Iori, G. & Caldarelli, G. ; Finger, K., Fricke, D. & Lux, T. Japan Imakubo, K., Soejima, Y.et al., Mexico, Martinez-Jaramillo, S., Alexandrova-Kabadjova, B., Bravo-Benitez, B. & Solórzano-Margain, J.P, Switzerland, Müller, J. Interbank credit lines as a channel of contagion. US, Demiralp, S., Preslopsky, B. & Whitesell, W.; Bech, M. L. & Atalay, E.T) The above-mentioned works by individual countries have shown in national banking systems the existence of stylized facts, that is, common statistical features that are with different networks. These financial networks tend to be sparse, with degree distributions with large tails, high clustering, and short average path lengths, and are dis-assortative. Part of the literature is focused on the characterization of the basic topology of these networks. Several studies have sought the most acceptable block description of financial networks, regardless of whether they contain a subset of closely related institutions, the core, and a subset of institutions, the periphery, which are loosely connected to each other and often connected to the core (Van Lelyveld, I. et al.; Kojaku , S., Cimini, G., Caldarelli, G. & Masuda, N.S.). We note that post-crisis the establishment of a central clearing counterparty (CCP) meant that many contracts were routed through a single institution (CCP). The potential benefits and risks of such a change in network topology are explored in Cont, R. & Kokholm, T.; Poce, G. et al; Buchanan, M.; Colander, D. et al.

Let us return to the models used by regulators and policymakers by considering simple representations of financial systems, describing them either as a set of isolated actors or as a homogeneous "mix" in which each

actor acts equally with all the others. However, the crisis of 2007-2008. she showed that this approach cannot give an adequate description of the highly heterogeneous and intertwined structure of the system, as well as the implications for society. With the onset of the crisis, the failed banks could not repay their debt, which led to the bankruptcy of other banks, in a cascading effect whose dynamics depended on the details of the patterns of interconnection. This approach to decision-making in the use of models can be explained by the theory of networks, by clarifying the interaction of the network structure, the heterogeneity of the individual characteristics of financial actors and the dynamics of the spread of risks, especially toxicity. The associated risk is "systematic", that means the products faced by the system as a whole, as well as in the collective phenomena studied by physics. "Each bank sets the interest rate for loans to other banks based on their perceived individual riskiness" (Garlaschelli, associate professor at IMT School for Advanced Studies Lucca and Leiden University, Netherlands). "However, if these banks are in turn connected to each other through other loans, then the real risk of collective default can be much higher. Since the existence of loans is a matter of confidentiality, new techniques need to be devised to guess the key properties of interbank business, networks of partial information. This is also crucial for central banks seeking to conduct reliable stress tests on the financial system. The non-trivial generalization of the statistical physics framework allowed us to solve this challenge in an original way."

So, the fact is that financial networks are one of the new frontiers of modern physics, but also the key role of statistical physics in providing a mathematical description of the relationship between microscopic and macroscopic properties of systems composed of many parts, including social and economic ones (Nature Reviews Physics).

With the end of the financial crisis, the role of the network for monitoring financial stability and designing macroprudential regulation is widely recognized. There is a consensus among policy makers and researchers that systemic risk must be studied and managed by adopting a network perspective. This certainly leads to the recommendation that it is necessary for institutions to adopt network models for a more comprehensive risk assessment. It is manifested in the political activity and discourse of the highest financial authorities, both in the USA and in the EU.

Scientific research in network theory seeks to solve problems with tools for network reconstruction and pattern detection. However, most of these tools only work on one problem. A current collaboration of network theorists from the IMT School for Advanced Study in Lucca (Italy), the University of Leiden and the Italian Research Council (CNR) has published a review article in the inaugural issue of the new journal Nature Reviews Physics that provides a common framework for solving multiple problems with a single tool.

Garlaschelli (IMT Lucca/Leiden) developed methods for the reconstruction of networks without access to all information. This is relevant, because in the financial world, where banks are only required to publish their total liabilities and loans, information is provided about who they lend to and from whom they borrow.

Lack of knowledge implies "hidden risk". If bank A lent money to bank B, which in turn lent money to unstable bank C, then bank A also becomes unstable. When central banks tested several tools for the reconstruction of the banking system, the one proposed by Garlaschelli and co-authors proved to be the most successful. Other independent tests gave the same result.

In pattern discovery, in this case, researchers have full information about a complex system and try to find structure. But they face two problems: it is unknown which properties are important, while there are many parameters. The first problem is solved by creating a randomized system that retains some features of the real world and comparing it to real life.

Garlaschelli points out: "We create a financial system with randomized connections between banks under the condition that each bank keeps the same number of connections it has in the real world and compare it to the Dutch banking system. From this comparison, we identify important properties of the system and even find early warning signals for crisis of 2008. Another problem is solved by analytically deriving the equations for the connection probabilities of pairs of nodes. This removes the need for numerical processing of a large number of parameters "but also". we discovered that in some cases networks behave as mediators between Fermi-Dirac systems, where particles do not they can be in the same state, and Bose-Einstein systems, where such a limitation does not exist. We recently identified a new mechanism responsible for breaking a centuries-

old assumption in statistical physics – namely, the equivalence of canonical and microcanonical ensembles, traditionally used to describe systems under soft and hard constraints."

Conclusion

I have been studying and researching an interdisciplinary approach to financial decision-making for almost a decade. From my experience, I discovered that many terms and concepts that I use in my research are inherently interdisciplinary (many different disciplines use them and give different meanings to the terms/concepts). An interdisciplinary approach helps me add depth and breadth to my analysis by adopting a holistic approach to learning. This is because I learned that if I only read papers from my home discipline (finance), I would exclude entire areas of knowledge. Interdisciplinarity taught me that 'knowledge' does not belong to anyone, and that made me far more curious and adventurous in my work!

Interdisciplinarity, in my opinion, makes a stronger researcher. Working in different disciplines often means stepping out of your comfort zone into unknown territory. This can be scary, but also very rewarding. Working within the area of finance in my research, I have developed strong critical thinking and problem solving skills. This experience was gained by using different literature, methods and types of sources to develop and answer my research questions, which one discipline alone could not fully encompass. Interdisciplinarity allows my research - and mom's - to reach its full potential, it is important for creating useful, well-rounded, relevant academic knowledge.

Future research is going in the direction of a quantum-informational holographic model of brain-consciousness-universe interactions based on Karl Pribram's holonomic neural networks, on the holographic quantum theory developed by David Bohm and on the non-locality property of the quantum field described by Hiroomi Umezawa. This model considers is an extension of Sir John Eccles' interactive dualism, the interconnection between brain and mind using quantum microsites called dendrons and psychons. These are fundamentals that continue with climate challenges, AI and the space technology stock market.

The recommendation for researchers, especially young scientists, is an in-depth analysis and finding traces of financial decision-making in loose new global flows/waves with an interdisciplinary approach.

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